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TECHNOLOGY TRANSFER IN CLEAN DEVELOPMENT MECHANISM AND HOST COUNTRIES' KNOWLEDGE BASE

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1. Introduction

The United Nations Framework Convention on Climate Change (UNFCCC) [2] and its Kyoto Protocol (KP) [3] initiated an innovative approach in addressing climate change by involving both developed and developing countries. The Clean Development Mechanism (CDM) is one of three market-based instruments of KP designed to allow flexibility in meeting targets of green house gas (GHG) reduction. Under the CDM scheme, governments and business entities from developed countries are allowed to offset their emissions liabilities by reducing or avoiding emissions in developing countries, where it is often cheaper to do so. The objective of the CDM as defined in Article 12 of KP is twofold: 1) to assist developed country parties in achieving compliance with their emission limitation and reduction commitments under the Protocol, and 2) to assist developing country parties in achieving sustainable development. Under the sustainable development agenda CDM projects, besides delivering various social and economic benefits, are expected to transfer climate friendly technologies and expertise to developing countries. Therefore, the CDM scheme is viewed as an effective means of subsidizing technological advancement of developing economies and, subsequently, placing them towards a more climate friendly growth trajectory.

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[2] UNFCCC entered into force on 21 March 1994. It has now been ratified by: 41 Annex I Parties, which includes OECD and EU Member countries and 16 other countries (mostly European countries with transition economies); and 148 non-Annex I Parties, including most developing countries.

[3] Kyoto Protocol of the UNFCCC is an agreement regulating global greenhouse gases emission trading. It was designed in 1997 and entered into force in February 2005 and has been ratified by 35 Annex I Parties and 120 non-Annex I Parties. Until now it has been the only agreement regulating emission trading scheme of the global scale.

Examples of CDM projects include installation of various renewable energy producing facilities, cutting the GHG emissions in chemical, cement, waste management and other industries through changing the processes or improving of energy efficiency. Like with many environmental other technologies in developing countries, GHG cutting technologies and related expertise are either not widely diffused, or even new to the project host countries (Aslam, 2001; Forsyth, 1998). On the other side, economical and technological frontrunner countries have big advantages in this aspect. Large amounts of R&D investment and special national programs such as promoting renewables and waste management practices, combined with stricter environmental standards have moved them to the technological frontier (Jaffe and Palmers, 1996; Newell, 1997, Blackman, 1999). With the start of CDM one would expect large flows of technologies and expertise from North-to-South.

However, the real experience with the CDM projects has not been always proving this sounding logical expectation. Studies following up the technology transfer statistics in CDM project report technology transfer happening for roughly one third of the projects (Haites etal, 2007, Seres 2008, Dechezlepretre *et al.*, 2008). Our study of a sample of 497 projects registered during the first two years after KP enforcement showed that less than half of them involved various degrees of foreign technology participation. More specifically, 94 projects (19%) fully relied on foreign technology; 109 projects (22%) reported about combination of foreign and local technologies or joint work of local and foreign engineers on the installation design. Given the high promises of technology transfer, it is striking that in over half (or 56%) of the projects reviewed by us the technology deployed was of local origin (See the Diagram below and the Annex I for cross country statistics).

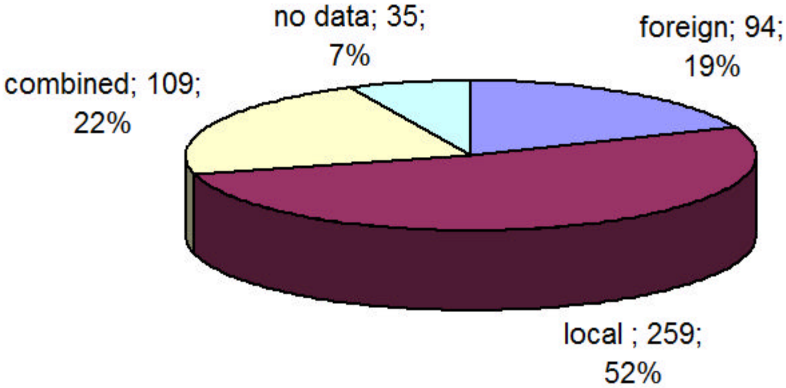

Diagram 1. Technology origin in CDM projects

Table 1. Technology providers' participation in CDM projects

Annex I countries		*Non-Annex / CDM project recipient countries*	
Australia	1	Brazil	59
Austria	1	Chile	11
Belgium	5	China	13
Canada	4	Colombia	1
Italy	5	Ecuador	2
Japan	13	El Salvador	1
Europe	1	Honduras	1
Denmark	19	India	145
France	11	Indonesia	2
Germany	21	Israel	1
Czech Republic	2	Malaysia	8
Ireland	41	Mexico	27
Netherlands	10	Nicaragua	1
New Zealand	2	Pakistan	1
Russia	1	Singapore	1
Spain	12	South Africa	2
UK	6	South Korea	1
USA	20	Taiwan	5
TOTAL 175		TOTAL 282	

Furthermore, in several projects companies from developing countries such as China, Malaysia, Taiwan and South Africa where identified as the technology providers for projects in other developing countries. In 282 projects technology was supplied by companies from developing countries, while technology providers from developed countries, the so-called Annex 1 countries, took part in 175 projects[4]. These figures might suggest that in the concept of "”North-to-South" technology transfer promoted within the framework CDM, the capabilities of the "South" have been somewhat underestimated. Therefore it might be reasonable to put forward the argument to stress importance of the local technological knowledge in developing countries in addressing goals of the Kyoto Protocol. We decided to take an initiative to shed some light on this perspective by analyzing the technological knowledge base of CDM host countries and investigating its relationship with the technology sourcing patterns in projects. The intention of the study is exploratory as to the best of our knowledge, there has hardly any research been done in this perspective. The central research question addressed in this study is wether the existing technological knowledge shapes the technology sourcing patterns in CDM projects.

Because it is a very specific case of climate friendly technologies, we had to focus in knowledge base in this narrow technology groups. This brought about methodological challenges in constructing indicators for measuring the technological knowledge of CDM host countries in the specific sectors of technologies and assessing the hypothesis that this knowledge influences the choice of technology source by CDM project initiators.

[4] Data about origin of technology providers in 68 project is was not available

The paper is structured in the following way. The second part of the paper provides more of the choice justification from the standpoint of the literature gap and discusses the theoretical concepts that ground the approach adopted in this study. The third part is methodological; it describes the data sources, variables and econometric technique. Econometric results are presented in the part four. Conclusions and implications appear in the last section of the paper.

Literature gap and conceptual issues

Before tackling the research question, we searched the literature on CDM to see if any attempt had been made to address this issue. There is a vast family of literature including policy papers, assessment studies, conceptual propositions, models and case studies building a dispersed discourse around the "CDM and technological development" topic (Olsen 2007). This literature addresses such issues as technology selection, transfer barriers and potential, spillover, building scenarios, etc (for example see Kaneko, 2006; Aslam, 2002; Millock, 2002). Yet the number of quantitative studies based on empirical results is still limited due to the rather short history of CDM implementation experience. However, it looks like more studies are on their way and preliminary results are fostering a new discourse. Recently there emerged a first wave of studies analyzing determinants of technology transfer patterns in CDM projects (Table 2) .

Table 2. Quantitative studies on determinants of technology transfer in CDM

Authors	*Factors studied*	*Sample size*
De Coninck *et al*, 2007	Technology origin country, capacity building, investment cost	63
Haites *et al*, 2007	Country size, GDP, technology type, project size*	860
Pueyo Velasco, 2007	Investment climate*, natural resource endowment*, climate policy institutions*	938
Seres, 2007	Technology needs, technological barriers, capital investment	2293
Dechezlepretre *et al*, 2008	Technological capabilities (ArCo index), presence of the credit buyer*, affiliation status*, project size*, macro-economic factors	644

These authors used different sized samples of CDM projects and built statistics on whether project involved local or foreign technology and expertise, hence produced counts of technology transfer evidences. Haites *et al* (2007) analyses the relationship with the project size and country's GDP and size; other studies attempted to include other more specific explanatory factors. De Conninck et al (2007) focused on technology origin and associated investment. Seres (2007) analysed if the technology transfer statistics is associated with technology needs and barriers. With respect to the focus of our paper interesting insights have been obtained from two studies; Puyeo Velasco, (2007) investigated the impacts of renewable energy endowments and/or potential of host countries on technology transfer patterns in CDM. These endowment factors cover the technically exploitable potential but do not consider the available expertise of a country in renewable energy technologies. Dechezlepretre *et al (*2008) included in the model the country-level technological capability developed by Archibugi and Coco (2004) in order to identify its influence on technology transfer under CDM projects. While it demonstrated that country level technological capability is positively associated with sourcing the technology from abroad, mixed results were obtained after controlling for different sectors, showing strong positive significance for energy and chemical industries and a negative influence in agriculture. These results have been interesting, both in terms of getting insights and challenging the application of such a broad technological capability indicator as ArCo index for this specific case. ArCo represents the country's overall technology and knowledge potential and is composed of country level science, technology, education and other indicators. The group of technologies applied under the CDM includes a number of environmental technologies such as renewable energy, energy efficiency, waste management, etc. This group represents rather a narrow niche and their R&D and diffusion dynamics differ from those of conventional technologies and products[5]. Therefore the country's capacity in these technologies could be different from the overall technological development level and aggregated S&T capacities. In a few aspects our study builds on observations and the model of Dechezlepretre *et al (*2008). However we have tried to be more specific in defining the technological knowledge base indicators and investigating their influence in technology sourcing statistics in CDM projects.

[5] For example the literature on environmental innovations highlights supremacy of state inducement factor (special policies) over market forces (like demand or competition) in success of environmental technologies.

Another distinct feature of our study is in the conceptual approach of the technology sourcing idea in CDM. The aforementioned studies focused on projects involving technology transfer, in other words cases of foreign technology application, and investigated factors influencing it. In contrast, the angle of our study is rather on projects using local technologies and factors affecting this choice. We suggest that behind this choice there is a history of evolution of the technology, as well as its diffusion in the CDM project host country which in turn is currently shaping CDM related developments in the country. Therefore understanding the knowledge base in the country is important if we want to understand why in most cases project developers go for local technologies.

Our empirical observations call first for theoretical grounding of the raised argument, and second for a more empirical setting in which macro level factors associated with knowledge base can be operationalized. Our attempts to explain it through knowledge base indicators have a number of compelling reasons. First, in the current debate of the post Kyoto perspective there is a need for a better understanding of technological development aspects, especially in regards to developing nations (Kline *et al*, 2004). Second, despite high political interest in this area, there are only a limited number of academic studies in general and to our knowledge there are no studies addressing this issue from the perspective of technological change and catching-up.

In order to understand why CDM project initiators in certain countries or technology sectors rely on local technologies and others on foreign we tried to see what the concepts on knowledge, technology base and technological capabilities can offer us.

Importance of the knowledge base of the country in its economic development and catching-up has been extensively highlighted in the economics literature. The idea of the knowledge economy has found imperative recognition in the policymaking domain and led to a paradigm shift in the whole concept of economic development (Foray and Lundval, 1996, Abramowitz and David, 1996). Now it is widely acknowledged that technological capabilities are an important strategic asset in boosting economic growth on national, sectoral and firm levels. Besides, technological capabilities are a necessary prerequisite, both in creation and diffusion of the technologies. At the same time it would be incorrect to ignore the importance of the technology transfer. Many studies have demonstrated that knowledge arrives with foreign direct investment. Therefore the idea of complementarity of foreign technology import with domestic technological effort as a most optimal recipe for promoting technical change and catching-up in developing countries has been repeatedly highlighted by the development economists (Radosevic, 1999).

In the context of climate change mitigation the role of technology is acknowledged both by supporter and detractors of the Kyoto protocol. Early adoption and learning in climate friendly technologies have been suggested as the most efficient ways of combating climate change (Thorn, 2008). Therefore it is very important to develop and diffuse the knowledge over the world, especially in developing countries whose rapid industrialization is threatening to outweigh all efforts on mitigation of climate change. Being the largest framework of collaboration with developing countries under climate change initiatives, CDM is seen and hoped to be a channel for the transfer of environmentally sound technologies Philibert (2005). However, after three years of growth experienced by CDM initiatives, another perspective seems to be emerging: developing countries not as passive receivers of the technology but as producers, sellers and even innovators. Within this perspective there is a need to analyse the current technological role and future potential of developing countries in mitigating climate change. Moreover the conceptual view of CDM as a channel of technology flow has to be changed to an institutional enabler for innovation and diffusion of CFT in developing countries. Having these prospects in its background, the present study attempts to analyse the current state of the technological knowledge base and its implications in CDM experience on the basis of empirical evidences and data on developing countries.

Methodology: Data source and variables

Data sources

In this study we are trying to explain the technology sourcing patterns in a sample of 497 CDM projects. Access to information about the projects is provided by Project design documents (PDD) made available through the UNFCCC website. Although these documents do not have an explicit objective to present detailed information about origin of technology deployed in the project, in most cases we were able to extract information about the project, its size, host company, affiliation status, technology origin, technology providers, credit buyer information, etc. In some cases it was necessary to supplement the revision of the project documents with checking additional documents from the UNFCCC, or search through other internet resources. Overall project statistics were obtained from the online database of UNEP Riso (2007).

Various country level data for constructing independent and control variables were acquired from the International Energy Agency (IEA), United States patent and Trademark Office (USPTO), United Nations Commodity Trade Statistics Database (COMTRADE), Science Citation Index Expanded (ISI/SCI-E) of the Institute for Scientific Information, and World Development Indicators (WDI) of the World Bank.

Constructing variables

<u>Dependent variable: Technology origin</u>

The present study has been designed to examine the origin of technology deployed in CDM projects. On the basis of the observations obtained through PDD documents we used three categories for technology sources: local, foreign, and combined, to indicate technology origin (T_ORIG) variable. Our application of multi categorical variables differs from approaches in other studies that use binary variables to indicate technology transfer evidence or absence of it (Dechezlepretre *et al.*2008; Haites, 2007; Seres 2008). Compatibility of their indicators with ours is in the definition of the technology transfer these authors apply. Technology transfer is allied with the import of equipment and/or knowledge from abroad. In our case we are studying technology origin (local versus foreign) and in quite a large number of cases (109 projects) it was impossible to judge if the technology and expertise applied in the project was completely of local or foreign origin. Therefore in addition to the categories “Local” and “Foreign” we introduced the category “Combined” for the projects that involved a combination of local and foreign technology and/or expertise. Examples of combined cases are when local engineers do the technical design the facility, but the machines to equip the facility are bought from abroad. Opposite cases often happen when foreign companies specialized in CDM projects bring their design and but involve local companies in supplying the parts for technological lines. In some projects, technology partially consisted of local and foreign equipment blocks compiled and put together (e.g. imported automated control system and locally produced power generator, or local biogas digesters and imported power cogeneration unit).

<u>Independent variables: Country’s knowledge base.</u>

The country and sectors specific technology and knowledge base is a complex multidimensional concept reflecting such aspects as the diffusion level of the technology which reflects the knowledge in application of the technology, availability of technology related R&D, production expertise in the country's specific sectors, availability of educational institutions, and technical potential in this area. Dealing with a CDM case requires looking into the indicators exclusively related to the generation and application of climate friendly technologies. Over 90% of CDM projects deal with renewable energy production, energy saving and biogas recovery technologies. Therefore we focused on the collection of data on these specific sub-sectors. Table 3 below presents the constructs that we applied to indicate the CDM technologies specific knowledge base in each country.

The first factor, the diffusion level of climate friendly technologies, is associated with production capacities and practical experience in climate friendly technologies. The assumption here is that the higher diffusion level of the technology represents better practical knowledge in this technology in the country. We suggest two proxies to measure it: the production of electricity from renewable energy sources and the share of export of these technologies. From the IEA database we obtained the data on electricity from renewable energy sources and calculated its share in the total national energy production mix (TPES) for 2005. This gave us our first independent variable RE_SHARE.

Similarly we calculated the share of climate friendly technologies in the total value of exported goods (CFT_EXP). The source for the export data was the UN Commodity Trade Statistics Database that uses the Harmonized Commodity Description and Coding System (HS1996). OECD has well defined typologies of technologies and specifying codes for environmental technologies in various sectors (Steenblik, 2005a, b). We restricted our search to codes covering the energy sector, such us energy production and saving (see annex III for codes used). Our methodological choice is again based on the dominance of energy technologies in overall CDM projects portfolio.

Table 3. Indicators proposed to measure knowledge base specific to CDM technologies

Constructs for CDM technologies knowledge base	*Data and measurements*	*Source of data*

Diffusion level of climate friendly technologies	?? Share of energy from hydro, wind, solar, geothermal, biomass in total primary energy supply ?? Share of climate friendly technologies in the flow of total export of goods	International Energy Agency UN Commodity Trade Statistics Database
Scientific effort in climate friendly technologies	?? Share of scientific articles in climate friendly technologies in total pool of scientific articles ?? N of patents in climate friendly technologies by inventor	Science Citation Index expanded US PTO database

The second group of variables represents the scientific or R&D related knowledge base of the countries, which can be measured through the number of patents filed in the fields of climate friendly technologies. Although many inventions are never patented in developing countries, patents can represent a valid proxy for a form of codified knowledge generated by profit seeking firms and organizations (Archibugi and Coco, 2003). We used the USPTO database to search data on each country because this office receives a greater number of foreign patent applications than any other patent office (ibid). The patent IPC codes for specific renewable energy technologies have been sourced from Johnstone et al (2008). Others covering such technologies as landfill gas recovery and energy efficiency were identified by us. The complete list of IPC codes used in the search is presented in the annex II. As it was expected, patent counts demonstrated a significant difference in performances between such countries like Israel and South Korea and the rest of the group. Roughly one third of the countries counted zero patens in climate friendly technologies. Due to this problem we had to convert the continuous variable into a dummy by introducing two new categories: “zero and low performers” and “medium and high-performers”. The grouping approach was based on using the median as a threshold for splitting the whole group of countries. Thus the variable PAT_dum indicates if a particular country belongs to the medium and high performers group (=1).

Armenia, Bangladesh, Bolivia, Cambodia, Guatemala, Honduras, Moldova, Mongolia, Morocco, Nepal, Nicaragua, Pakistan, Chile, Costa Rica, Dominican Republic, Ecuador, El Salvador	Zero and low performers (below median group)
South Africa, Argentina, Philippines, Mexico, China, Cyprus, India, Sri Lanka, Colombia, Peru, Brazil, Jamaica, Nigeria, Egypt, Indonesia, Malaysia, Viet Nam, Israel , Republic of Korea	Medium and high performers (above median group)

Another important source of codified knowledge is scientific literature (Archibugi and Coco, 2003). It represents the knowledge generated in universities, research centers, and other publicly, as well as privately funded research organizations. The variable indicating the share of scientific articles on climate friendly technology studies in the total number of scientific articles (FCT_PUBL) was obtained from publication counts from the Science Citation Index Expanded (SCI-E) database in ISI's Web of Science. This database is known to be the most comprehensive and validated, and believed not to be heavily discriminating against developing countries (Archibugi and Coco, 2003). For the search strategy we employed a lexical query consisting of a small set of keywords. Themes of publications have been visually revised to ensure relevance to the topic. Several articles have been excluded based on the irrelevance of the journal's subject area.

Control variables

Additional variables that should be taken into consideration in the econometric analysis are project specific characteristics and country specific variables.

Project specific variables such as the size, ownership status of the project operator company, i.e. subsidiary or foreign partner, and existence of similar projects have been taken into consideration Previous quantitative studies have established that there are economies of scale in technology transfer: all other things being equal, transfers in large projects are more likely (Dechezlepretre et al.2008; Haites, 2007; Seres 2008). Following this we included a project size variable (P_SIZE) in the model. Furthermore, these studies established that probability of transfer is 50% higher when the project is developed in a subsidiary of an Annex 1 company (Dechezlepretre et al. 2008). We have recorded the information about the evidence of host projects being a subsidiary of a foreign partner and introduced the subsidiary dummy indicator (SUBSID_D). Besides this, the previous study also established that the probability of involvement of any sort of foreign technology decreases with the number of projects using the same type of technology in the country (Dechezlepretre *et al,* 2008). Following this finding we controlled for these factors by introducing the variable SIMILAR, which indicates the number of CDM projects in the same technology for each country.

Country specific variables included in our econometric model are country size, income level, trade and local renewable energy resource endowment. Country size is treated in our model through Log of population (LN_POP). It captures the effect of country size on the propensity to import the technology. Theoretically, large countries have a more diversified industrial base, which means higher chances of having technology domestically available. A similar argument goes for the GDP per capita indicator (GDP_CAP). Countries with a higher level of wealth production tend to have a better technological base, and are likely to have technologies in their domestic market. However the observations on these variables in other studies using different sized samples showed varied results (Seres, 2007, Haites *et al,* 2006, Dechezlepretre *et al*, 2008)

Previous studies on technology transfer in CDM were in line with general economic literature in providing empirical evidences that transfer of technology is associated with higher FDI and international trade activities (Pueyo Velasco, 2007; Dechezlepretre et al.2008). To capture this effect we introduced the variable TRADE, which is the sum of the trade value of exports and imports of all commodities during the years 2002-2005 divided by the country's GDP. The control variable related to FDI was avoided for the following reasons: first, participation of the foreign capital is already captured by the subsidiary dummy variable; second, FDI/GDP indicator showed high correlation with other variables, which may distort the regression results.

The renewable energy resources endowment factor can represent a country's capacity to host new renewable energy projects. It relates to the idea of technology brought along with resource seeking FDI. Pueyo Velasco (2007) who studied this relationship in the case of CDM allied investment established that higher resources in biomass increased the propensity of attracting foreign technology in CDM projects. We have used the variable REN_RES to indicate a country's renewable energy resources including biomass, waste, hydro, solar, wind, geothermal and ocean tide. This indicator is presented as a share of the total primary energy supply of the country.

Table 4 summarizes the information on variables we have applied, their descriptive statistics and expected effect on the outcome. Table 5 presents the correlation matrix for all variables.

Table 4. Definition of variables and summary statistics

variables	*Description*	*Obs*	*Mean*	*Std. Dev.*	*Exp outcome*
P_SIZE	Log of the size of the project (expected annual reductions in ktCO2eq)	460	3.709	1.507	-
SUBSID_D	= 1 if the project host company is the subsidiary of a foreign partner, 0 otherwise	460	0.220	0.414	-
SIMILAR	Natural Log of the number of projects already using the same type of technology within the host country	460	2.613	1.325	+
TRADE	sum of annual values of exports and imports of all commodities divided by the value of GDP (average for 2002-2005)	460	0.489	0.320	-
LN_POP	Natural Log of total population in million (2005)	460	5.449	1.672	+
GDP_CAP	GDP per capita (2005) in thousand USD	460	3.418	3.346	+
CFT_PUBL	Share (%) of scientific articles in climate friendly technologies in a national pool of scientific publications	460	0.515	0.276	+
PAT_dum	=1, if country has more than 1 patent in climate friendly technologies, =0, if country has zero or 1 patents	460	2.865	0.502	+
CFT_EXP	Share (%) of climate friendly technologies in total value of exported goods, average of 2002-2005	460	1.402	0.826	+
RE_SHARE	Share (%) of renewable energy in the	460	0.543	0.567	+

	national total primary energy supply for 2005.	

Table 5. Correlation matrix of variables

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1) T_ORI	1.00									
(2) P_SIZE	0.15	1.00								
(3) SUBSID_D	0.57	0.19	1.00							
(4) SIMILAR	-0.11	-0.31	0.03	1.00						
(5) TRADE	0.32	0.10	-0.03	-0.25	1.00					
(6) LN_POP	-0.36	-0.02	-0.25	0.50	-0.44	1.00				
(7) GDP_CAP	0.29	0.00	0.33	-0.09	0.23	-0.57	1.00			
(8) CFT_PUBL	-0.30	-0.15	-0.32	0.20	-0.10	0.41	-0.47	1.00		
(9) PAT_dum	-0.05	-0.08	-0.02	0.47	-0.16	0.59	0.01	0.17	1.00	
(10) CFT_EXP	0.08	0.04	0.29	0.15	-0.06	-0.24	0.43	-0.43	0.02	1.00
(11) RE_SHARE	0.16	-0.01	0.20	-0.14	-0.11	-0.35	0.17	-0.45	-0.09	0.45

Results

The dependent variable T_ORI indicating technology source in each project is a categorical variable with three possible outcomes: local, foreign and combined (Table 6). It is appropriate to use a multinomial logistic regression model to estimate the effect of knowledge base indicators on the choice of technology source (Greene, 2003; Long and Freese 2006). In the analysis to follow, 'foreign' was chosen to be the reference group.

Table 6. Distribution among outcome categories of the dependent variable T_ORI

Outcome categories	*Frequency*	*Percent*	*Cumulative.*
local	257	55.87	55.87
foreign	94	20.43	76.3
combined	109	23.7	100
Total	460	100	

The results of the multinomial logit estimates are presented in table 7. Both models show the estimates of the choice of local technology and combined technology sources over the default category of foreign technology. Model 1 includes the results for the control variables only, whereas Model 2 also incorporates the independent variables. This table shows only the estimates for each category against the default category (foreign origin). To check whether there is a different effect of the independent variables on the different choice of technology origin, we can use odds ratios (*e^b and e^bStdX*) presented in table 8. This table decomposes the effect of the independent variables on the technology source into binary choice models. If the value of the binary choice is greater than 1, it indicates an effect of independent variable on selecting one technology source over another; a value smaller than 1 indicates an effect in the opposite direction. Significance of the effect can be judged by significance of the associated coefficients (*B*) presented in the same table.

The results in tables 7 and 8 show that the scientific contribution in terms of publications in climate friendly technologies is expected to have a positive effect on the use of local over imported technologies (5% significance), and on combined over imported technologies (10% significance) in CDM projects. Results for comparison between combined and imported technologies do not show significance; therefore we are not able to draw strong conclusions.

The results for the influence of patenting activities show strong negative effect on using purely local technology and to the contrary seem to be strongly associated with a preference for combined technology over local. Positive association is also observed on case of the imported over local, though the result is slightly less statistically significant. The results are quite confusing and require careful interpretation. One suggestion is that the countries with the largest patenting effort prefer collaborating with foreign partners in CDM projects. Another explanation is the weak institute and practice of patenting in developing countries which might cause the large occurrence of zero- and one-patent countries in our sample. However there could be other explanations, so we leave the question open for now.

Results on the effect of the country's export of renewable energy and CFT on the preference of local technology over imported had positive, stable and strong significance in the regression model. A slightly smaller with 5% significance, but still positive coefficient is associated with preference of combined over imported technologies. This logically supports the idea that availability of the technology on the local market decreases the propensity of bringing similar technology from abroad.

Countries' renewable energy production data showed a rather modest but positive effect towards a preference of local over imported technologies. This can be stated with the acceptable confidence level (10% significance). This result still allows us to support our argument about the importance of practical experience and availability of local expertise in making the choice for local technologies in CDM projects. Results for combined technologies didn't show results with sufficient significance level; therefore we restrain ourselves from using it for further interpretation.

It would also be informative to present the results for control variables. Project size –the first micro (project) level variable- showed consistency in negative influence on choice of both local and combined over imported technologies. This confirms findings of previous studies saying that larger CDM projects mostly rely on foreign technology and smaller projects source local technology. We would add that smaller projects rely almost equally on local or combined sources of technology (though with very tiny preference on combined option), rather than exclusively on foreign technologies.

Results for subsidiary effect show that project implementers that have an affiliation with a foreign company strongly prefer combined technologies over purely local and purely foreign technologies. This effect is also strong in the choice of foreign technologies over local ones. This observation is also in line with findings of previous studies.

The existence of other, similar projects increases the propensity of using local and combined technologies over foreign ones. This is probably due to the local availability of technologies which leads to a higher number of projects in the same technological sector. It has to be noted that the coefficient for combined technologies is slightly higher, meaning that project developers have a slightly higher preference for combined over purely local sourcing.

Talking about the effect of macro level economic indicators, our model 2 showed a statistically significant positive effect of the country size and somewhat less significant effect (both statistically and in terms of coefficient) of income level on the preference for local over foreign and combined technologies. Results for other categories are not statistically significant and the effect of the country size on the choice between combined and imported technologies can not be predicted assertively. Thus our results regarding the role of the size and economic performance of the country seem to be in contrast with previous studies proposing a peripheral nature of these indicators in explanation of technology transfer statistics.

But the finding on the role of trade openness of the country is quite consistent with previous studies. Trade indicators show a rather strong association with the application of combined technologies (to more extent) and foreign technologies (to lesser extent), and has a negative association with the application of purely local technologies. Hence, this result also confirms the argument that trade openness makes the import of technologies for CDM projects easier.

Table 7. Multinomial logit estimated

	Model 1		Model 2	
	Local	Combined	Local	Combined
P_SIZE	-0.388***	-0.419***	-0.529***	-0.453***
	(0.105)	(0.127)	(0.121)	(0.137)
SUBSID_D	-1.976***	1.978***	-2.210***	1.759***
	(0.469)	(0.427)	(0.513)	(0.447)
SIMILAR	0.579***	0.695***	0.363**	0.546***
	(0.145)	(0.169)	(0.157)	(0.177)
TRADE	-2.774***	0.873**	-1.610**	0.898*
	(0.719)	(0.455)	(0.805)	(0.511)
LN_POP	0.121*	-0.089	0.722***	-0.123
	(0.117)	(0.146)	(0.208)	(0.213)
GDP_CAP	0.030	-0.032	0.113*	-0.087
	(0.047)	(0.061)	(0.071)	(0.086)
CFT_PUBL			1.722**	0.162
			(0.689)	(0.839)
PAT_dum			-2.287**	0.630
			(0.778)	(0.747)
CFT_EXP			1.031***	0.365*
			(0.242)	(0.246)
RE_SHARE			0.056*	0.047*
			(0.033)	(0.032)

_cons	2.078***	-0.418	-1.507	-0.894
	(0.837)	(0.911)	(1.290)	(1.163)
Log likelihood	*-296.46*		*-273.99*	
Prob > chi2	*0.0000*		*0.0000*	
Pseudo R2	*0.3496*		*0.3989*	

a. foreign origin is the comparison group
b. *significant at 10%; **significant at 5%; *** significant at 1% level
c. Robust standard errors in parentheses
d. N=460

Table 8. Effect of independent variables on the choice between different technology origins

		Local over Combined	*Local over Imported*	*Combined over Local*	*Combined over Imported*	*Imported Over Local*	*Imported over Combined*
CFT_PUBL	*B*	1.561**	1.722*	-1.561**	0.162	-1.722*	-0.162
	e^b	4.761	5.598	0.21	1.176	0.179	0.851
SD=0.28	*e^bStdX*	1.538	1.609	0.65	1.046	0.622	0.956
PAT_dum	*B*	-2.917***	-2.287**	2.917***	0.63	2.287**	-0.63
	e^b	0.054	0.102	18.488	1.877	9.848	0.533
SD=0.31	*e^bStdX*	0.406	0.493	2.462	1.215	2.027	0.823
CFT_EXP	*B*	0.667**	1.031***	-0.667**	0.365	-1.031***	-0.365
	e^b	1.948	2.805	0.513	1.44	0.357	0.694
SD=0.82	*e^bStdX*	1.734	2.344	0.577	1.352	0.427	0.74
RE_SHARE	*B*	0.009	0.05624*	-0.00886	0.04738	-0.05624*	-0.0474
	e^b	1.009	1.0578	0.9912	1.0485	0.9453	0.9537
SD=5.68	*e^bStdX*	1.052	1.3763	0.9509	1.3087	0.7266	0.7641

b = raw coefficient

e^b = exp(b) = factor change in odds for unit increase in X

*e^bStdX = exp(b*SD of X) = change in odds for SD increase in X*

Conclusion and implications

In conclusion of the results we will refer to the research question addressed in this study:

Does the technological knowledge base of a host country determine the technology sourcing patterns in the CDM projects?

This study has demonstrated that technological knowledge in climate friendly technologies (to a certain degree) can explain the technology sourcing pattern in CDM. With our empirical results we can declare that countries with bigger experience in climate friendly technologies have a higher probability in using local and combined technologies in CDM projects. This is especially confirmed through the export indicators, implying that if the country produces and exports technologies there is no need to import technologies for their CDM projects.

However, the results for scientific knowledge are quite intricate, which gives room to a range of speculations. While scientific effort in terms of publications seems to associate positively with local and mixed technology sourcing, patenting activities show a positive association with mixed and foreign technologies, but a negative one with local technologies. We are currently not capable to give a complete explanation. Possibly the countries with high patenting statistics like Israel, South Korea and Cyprus implement more joint projects with overseas partners that bring foreign technology along. On the other hand in the countries where CDM projects rely mostly on local technology, the patent institute possibly is not very well developed, or the local technology developers rely on other mechanisms to protect their technology. However there might be other explanations and we would suggest further investigation of this issue.

Results of the study suggest implications both for developing countries striving to address economic problems, and for developed countries which are interested in reaching emission reduction targets. Developing countries with better technical and scientific expertise would not need to depend on foreign technology to initiate CDM projects, which allows avoiding transaction costs associated with importing technology from abroad and decreases the overall investment cost of the project. Besides, local production of the technology is allied with other socio-economic benefits such us employment of local people in manufacturing and other stages of the production chain. Sourcing the local technology or cooperating with foreign technology providers spurs the economic base of the local producers.

The interest of the developed countries -the purchasers of carbon emission credits generated by CDM projects- is in the economic cost-effectiveness of the project. In the short and long-run, reliance on the domestic expertise and technology can secure higher cost-effectiveness of the investment in projects and reduce the overall cost of climate change mitigation.

The study opens new avenues for further research. In particular, it would be interesting to disaggregate the data by technology type and investigate trends per technology subsector. This may also allow us to understand and explain our present results in a more comprehensive way. Finally, it is important to investigate the role of environmental and renewable energy policies in building the technological and knowledge base of a country. It is well established that for development, innovation and diffusion of environmental technologies the role of the right state policies is of high importance (Lanjouw and Mody, 1993; Jaffe and Stavins, 1995). In the context of technology transfer under CDM, studying renewable and energy policies of developing countries and their role in CDM associated sourcing technologies from abroad or developing them locally, might give interesting perspectives.

It is also necessary to mention that this study showed the possibility for methodological contribution in measuring the knowledge base of the country in the specific niche of climate friendly technologies. Results of the study demonstrated that the knowledge base indicators proposed by us could be used to explain to a certain extent the technology transfer patterns in CDM projects, although the application of them might need some cautiousness. This is especially true in the case of patent data, which presented two difficulties to us: first in terms of availability, and second in the correct interpretation of its impact in the model.

Abramowitz, M. (1989), “Thinking about Growth”, Cambridge University Press, Cambridge.

Archibugi, D., Coco, A., 2004. “A new indicator of technological capabilities for developed and developing countries (ArCo)”. World Development 32 (4), 629–654.

Aslam, M.A. (2001), “Technology transfer under the CDM: Materializing the myth in the Japanese context?” Climate Policy 1 (2001) 451–464

Blackman, A. (1999), “The economics of technology diffusion: implications for climate policy in developing countries”. Discussion Paper 99–42, Resources For the Future, Washington, DC.

de Coninck, H., Haake, F., van der Linden, N. (2007), “Technology transfer in the Clean Development Mechanism”. Climate Policy 7, 444–456.

Dechezlepreˆtre, A., Glachant, M., Me´nie`rea, Y. (2008), “The Clean Development Mechanism and the international diffusion of technologies: an empirical study”. Energy Policy 36, 1273–1283.

Ellis, J., Kamel, S. (2007), “Overcoming Barriers to Clean Development Mechanism Projects”. OECD, Paris.

Ellis, J., Winkler, H., Corfee-Morlot, J., Gagnon-Lebrun, F., (2007), “CDM: taking stock and looking forward”. Energy Policy 35, 15–28.

Forsyth, T. (1998), "Technology transfer and the climate change debate", Environment, 40(9), pp.16-20, 39-43

Greene, W.H., (2003), “Econometric Analysis”, fifth ed. Upper Saddle River, NJ: Prentice-Hall.

Haites, E.; Duan, M. And Seres, S. (2006), “Technology Transfer by CDM Projects”. Margaree Consultants and Tsinghua University. Basic Project

Jaffe, A.B. and K. Palmers (1996), “Environmental regulation and innovation: a panel data study”, NBER Working Paper 5545, Cambridge MA.

Johnstone, Nick, Hascic, Ivan and Popp, David C. (2008), "Renewable Energy Policies and Technological Innovation: Evidence Based on Patent Counts" (January 2008). NBER Working Paper No. W13760 Available at SSRN: http://ssrn.com/abstract=1088674

Kaneko, Sh., Yonamine, A, Yong Jung, T. (2006), ‘Technology choice and CDM projects in China: case study of a small steel company in Shandong Province', Energy Policy, Volume 34, Issue 10 , July 2006, Pages 1139-1151

Kline, D. M., Vimmerstedt, L., Benioff, R. (2004), "Clean energy technology transfer: A review of programs under the UNFCCC", Mitigation and Adaptation Strategies for Global Change, 9, pp.1–35

Lanjouw, J. O., and A. Mody (1993), "Stimulating Innovation and the International Diffusion of Environmentally Responsive Technology: The Role of Expenditures and Institutions," mimeo.

Long. J.S and J. Freese (2003), "Regression Models for Categorical Dependent Variables Using Stata". rev. ed. College Station, TX: Stata Press

Lundvall, B. and Johnson, B., (1994), "The Learning Economy", Journal of Industry Studies,

Millock, K., (2002), "Technology transfers in the Clean Development Mechanism: an incentives issue. Environment and Development Economics 7, 449–466.

Newell, R. G. (1997), "Environmental policy and technological change: the effects of economic incentives and direct regulation on energy-saving innovation". Ph.D. Thesis, Harvard University, Cambridge, MA.

OECD (1996*c*), "Transitions to Learning Economies and Societies", Paris.

Olsen, K. (2007) "The Clean Development Mechanism's contribution to sustainable development: a review of the literature". Climatic Change 84, 59–73.

Philibert, C. (2005) "The role of technological development and policies in a post-Kyoto climate regime." Climate Policy 5, 291–308.

Pueyo Velasco, A. (2007) "Variable Underpinning technology transfer through CDM projects" Join Implementation Quarterly, Volume 13, N3, October 2007, Page 5-7

Radosevic, S. (1999) "International Technology Transfer and Catch-up in Economic Development". Cheltenham: Edward Elgar

Schneider, M., Holzer, A., Hoffmann, V. (2008) "Understanding the CDM's contribution to technology transfer". Energy Policy, doi:10.1016/j.enpol.2008.04.009

Seres, S. (2007). "Analysis of technology transfer in CDM Projects". Prepared for UNFCCC Registration & Issuance Unit CDM/SDM.

Steenblik, R. (2005a) "Environmental Goods: A Comparison of the APEC and the OECD lists", OECD Trade and Environment Working Paper n. 2005–04. OECD, Paris.

Steenblik, R., (2005b) "Liberalisation of Trade in Renewable-energy Products and Associated Goods: Charcoal, Solar Photovoltaic Systems, and Wind Pumps and Turbines", OECD Trade and Environment Working Paper n. 2005–07. OECD, Paris.

Thorne, S. (2008) "Towards a framework of clean energy technology receptivity". Energy Policy (2008), doi:10.1016/j.enpol.2008.02.031

UN Comtrade, (2008) United Nations Commodity Trade Statistics Database, available at http://comtrade.un.org/db/

UNEP Riso, (2007) CDM/JI Pipeline Analysis and Database /http://cdmpipeline. org/S, April 2007

World Bank, (2008). World Development Indicators (WDI), on-line database. The World Bank, Washington, DC, available at www.**world**bank.org/data

Annex I. Statistics of technology origin in CDM projects (sample of 460 projects)

host country name	local	imported	combined	Total
India	141	3	9	153
Brazil	43	7	30	80
Mexico	27	3	42	72
China	18	26	2	46
Chile	11	3	0	14
Malaysia	1	3	7	11
Ecuador	2	6	0	8
Philippines	1	1	6	8
Republic of Korea	1	5	1	7
Colombia	2	4	0	6
Indonesia	2	4	0	6
Argentina	0	5	0	5
South Africa	1	0	3	4
Honduras	1	2	0	3
Moldova	0	0	3	3
Armenia	0	2	0	2
Bangladesh	0	2	0	2
Costa Rica	1	1	0	2
Cyprus	0	2	0	2
Egypt	0	2	0	2
El Salvador	2	0	0	2
Guatemala	1	1	0	2
Israel	1	1	0	2
Morocco	0	1	1	2
Nepal	0	0	2	2
Nicaragua	1	1	0	2
Peru	0	2	0	2
Viet Nam	0	2	0	2
Bolivia	0	0	1	1
Cambodia	0	1	0	1
Dominican Republic	0	1	0	1

Jamaica	0	1	0	1
Mongolia	0	0	1	1
Nigeria	0	1	0	1
Pakistan	0	0	1	1
Sri Lanka	0	1	0	1
Total	257	94	109	460

Notes: initial sample was 497 projects. Due to the missing data 37 observations had to be dropped out of the analysis.

Annex II. Patent data: USPTO

Date of extraction: July 15, 2008

Source: http://patft1.uspto.gov/netahtml/PTO/search-adv.htm

US Patent & Trademark Office, Patent Full Text and Image Database

Searching 1976 to present

BIOGAS	icl/A01C3/02 OR icl/A01C3/04 OR icl/A01C3/06 OR icl/A01C3/08
BIOMASS	icl/B01J41/16 OR icl/C10L5/42 OR icl/C10L5/44 OR icl/C10L1/14 OR icl/F02B43/08
GEOTHERMAL	icl/F24J3$ OR icl/F03G4$ OR icl/H02N10/00
HYDROPOWER	icl/F03B13/06 OR icl/F03B13/08 OR icl/F03B13/10'
LANDFILL	icl/B09B1/00 OR icl/B09C1/00
OCEAN	icl/F03B13/12 OR icl/F03B13/14 OR icl/F03B13/16 OR icl/F03B13/18 OR icl/F03B13/20 OR icl/F03B13/22 OR icl/F03B13/24 OR icl/F03G7/04 OR icl/F03G7/05 OR icl/F03B7/00
SOLAR	icl/F03G6$ OR icl/F24J2$ OR icl/F25B27/00 OR icl/F26B3/28 OR icl/H01L31/042 OR icl/H02N6/00 OR icl/E04D13/18 OR icl/B60L8/00
WIND	icl/F03D1$ OR icl/F03D3$ OR icl/F03D5$ OR icl/F03D7$ OR icl/F03D9$ OR icl/F03D11$ OR icl/B60L8/00 OR icl/B63H13/00

Example 1: "Query all wind patents, German inventor":
icn/DE AND (icl/F03D1$ OR icl/F03D3$ OR icl/F03D5$ OR icl/F03D7$ OR icl/F03D9$ OR icl/F03D11$ OR icl/B60L8/00 OR icl/B63H13/00)

Example 2: "Query all landfill patent, Indian assignee":
acn/IN AND (icl/B09B1/00 OR icl/B09C1/00)

Note: As we did not have full access to a (current) offline version of the USPTO patent database, we used a php/cURL script to automatically extract the numbers from the USPTO website. This method is not recommended for bulk downloads, as you "may be denied access to the server without notice".

Note: We are well aware of the fact that IPC codes in the USPTO database have not been cleaned. E.g., A01C3/02 also appears as A01C003/02. However, due to restrictions placed on the search interface, we could not use both variants in one query. Taking the union of the two might result in double counts.

Annex III. Export data: Code Description

Renewable energies	
2207.10	Ethanol
2905.11	Methanol
4401.10	Fuel wood, in logs, in billets, twigs, faggots or similar forms
4401.30	Sawdust and wood waste and scrap, whether or not agglomerated in logs, riquettes, pellets or similar forms
7321.13	Cooking appliances and plate warmers for solid fuel, iron or steel
7321.83	Non electrical domestic appliances for liquid fuel
8410.11	Of a power not exceeding 1,000 kW
8410.12	Of a power exceeding 1,000 kW but not exceeding 10,000 kW
8410.13	Of a power exceeding 10,000 kW. 8410.90 — Parts including regulators
8410.90	Hydraulic turbines and water wheels; parts including regulators
8413.81	Pumps for liquids, whether fitted with a measuring device or not; [Wind turbine pump]
8419.11	Instantaneous gas water heaters
8419.19	Instantaneous or storage water heaters, non-electric – other [solar water heaters]
8502.31	Electric generating sets and rotary converters – Wind powered
8502.40	Electric generating sets and rotary converters [a generating set combining an electric generator and either a hydraulic turbine or a Sterling engine]
8541.40	Photosensitive semiconductor devices, including photovoltaic cells whether sssembled in modules or made up into panels; lightemitting diodes
Energy savings and management	
3815.00	Catalysts
7008.00	Multiple-walled insulating units of glass
7019.90	Other glass fibre products
8404.20	Condensers for steam or other vapour power units
8409.99	Parts suitable for use solely or principally with the engines of HS 8407 or 8408; other
8418.69	Heat pumps

8419.50	Heat exchange units
8419.90	Parts for heat exchange equipment
8539.31	Fluorescent lamps, hot cathode
8543.19	Fuel cells
9028.10	Gas supply, production and calibrating metres
9028.20	Liquid supply, production and calibrating metres
9032.10	Thermostats

Source: Steenblik (2005a, b).